

## Eleanor M. Waxman

### EDUCATION

**University of Colorado at Boulder**, Ph.D. in Chemistry, December 2015. Graduate GPA: 3.827

**California Institute of Technology**, B.S. with honors in Chemistry, June 2008. GPA: 3.7, Chemistry GPA: 3.8

**University of Edinburgh**, Edinburgh, Scotland, September-December 2006

### RESEARCH EXPERIENCE

**Research Scientist**, NOAA CSL, December 2020 – present

- LIF operation for NO measurements

**Research Chemist**, NIST Boulder, June 2017-December 2020

- First field deployment of a mid-infrared DCS to measure ethane and heavy hydrocarbons at a drilling site.
- Measured acetone and isopropanol from a controlled release using a mid-infrared DCS system.
- Fielded a dual comb system to measure emissions of CH<sub>4</sub> and C<sub>2</sub>H<sub>2</sub> from controlled leaks using a UAS.
- Measured CO<sub>2</sub>, CH<sub>4</sub>, and H<sub>2</sub>O across the city of Boulder using a dual frequency comb spectrometer and coupled with Gaussian plume modeling to quantify city emissions. Agreed within 30% of the city bottom-up inventory, demonstrating a new instrument for top-down measurements.

**Postdoctoral Research Associate**, NIST Boulder, Dr. Nathan Newbury, postdoc advisor, June 2015 to June 2017

- Ran the first comparison between two dual frequency comb instruments to determine instrument accuracy, precision, and repeatability. Experiment was performed over the open atmosphere, rather than in a laboratory with an open-pass cell. This enabled a comparison over a wide range of atmospheric conditions and trace gas concentrations.
- Performed first frequency comb measurements of broad-band gas-phase species in the laboratory.

**Graduate Research Assistant**, University of Colorado Boulder, Prof. Rainer Volkamer, Ph.D. advisor, Aug. 2008 to June 2015

- Used atmospheric simulation chambers to probe glyoxal uptake onto model inorganic aerosols to study effects of chemical composition, pH, RH, and aerosol liquid water on products formed, product reversibility, and Henry's law constants.
- Developed a novel method for measuring salting constants for water soluble aerosol precursor molecules using a mass-spectrometry and GC-FID.
- Identified products formed in glyoxal aerosol using ultra high resolution nano-DESI mass spectrometry, from which aerosol phase mechanisms for product formation can be inferred.
- Modeled SOA formation from glyoxal in Mexico City. Determined that glyoxal can form up to ~20% of the measured aerosol mass and that it can significantly help close the aerosol O/C gap, but by itself is not sufficient.
- Operated Cavity-Enhanced DOAS instruments (blue and UV ranges) to measure the gas-phase concentrations of NO<sub>2</sub>, glyoxal, O<sub>4</sub>, water, and HONO in both the field (CalNex 2010) and laboratory (PSI, Euphore, NCAR).

**Undergrad Research Assistant**, Caltech, Prof. Geoff Blake, June 2007-December 2007

- Assisted with building terahertz time domain system for studies of molecules found in interstellar space.

**Summer Undergrad Research Fellow**, Caltech, Prof. Jack Beauchamp, March-August 2006

- Studied ozonolysis of specific amino acids in model peptides using force-induced droplet ionization in conjunction with an electrospray quadrupole mass spectrometer to determine the products of and develop mechanisms for peptide ozonolysis.
- Studied amino acid and water clustering using electrospray quadupole mass spectrometry.

**REU Fellow**, University of Connecticut, Prof. Richard Parnas, June-August 2005

- Studied rheology of wheat gluten/additive mixtures in acetic acid to determine the reaction rates.
- Used atomic force microscopy to study surface structure and elasticity of wheat gluten/polymer blends.

### GRANTS

- NIST Technology Partnership Office, Co-I. Outdoor Trace Gas Monitoring Instrument for Industrial Applications. Award period: Jan. 2020 – Dec 2020. Award amount: \$250,000 USD
- NASA ROSES Instrument Incubator, Co-I. Frequency Comb Spectrometer for Satellite Atmospheric Remote Sensing. Award period: Mar. 2020-Sept. 2021. Award amount: \$1M USD.
- JPL/Caltech Center Innovation Fund, NIST Co-I. STARS – Spectroscopy Towards occultation for Atmospheric Remote Sensing. Award period: Jan. 2020-Sept. 2020. Award amount: \$100,000 USD

### AWARDS

- DOC Gold Award (shared) for spectroscopy, November 2020
- CO-Labs Governor's Award for High Impact Research, November 2019
- National Research Council Postdoctoral Research Fellowship, February 2015
- CIRES Graduate Research Fellowship, Fall 2014
- Graduate Teaching Award for General Chemistry, Fall 2008, Fall 2013
- Graduate Teaching Award for Analytical Chemistry, Spring 2009, Spring 2013
- NSF Graduate Research Fellowship, September 2009
- CU Department of Chemistry and Biochemistry Fellowship, August 2008

## PUBLICATIONS

Estimating vehicle carbon dioxide emissions from Boulder, Colorado using horizontal path-integrated column measurements. E.M. Waxman, K.C. Cossel, F.R. Giorgetta, G.-W. Truong, W.C. Swann, I. Coddington, N.R. Newbury (2019), *Atmos. Chem. Phys.*, 19, 4177-4192, <https://doi.org/10.5194/acp-19-4177-2019>.

Mid-infrared dual-comb spectroscopy of volatile organic compounds across long open-air paths. G. Ycas, F.R. Giorgetta, K.C. Cossel, E.M. Waxman, E. Baumann, N.R. Newbury, I. Coddington (2019), *Optica*, 6, 165-168, <https://doi.org/10.1364/OPTICA.6.000165>.

Broadband coherent cavity-enhanced dual comb spectroscopy. N. Hoghooghi, R.J. Wright, W.C. Swann, E.M. Waxman, I. Coddington, G.B. Rieker (2019), *Optica*, 6, 28-33, <https://doi.org/10.1364/OPTICA.6.000028>.

Real-time liquid-phase organic reaction monitoring with mid-infrared dual frequency comb attenuated total reflectance spectroscopy. D.I. Herman, E.M. Waxman, G. Ycas, F.R. Giorgetta, N.R. Newbury, I.R. Coddington (2019), *J. Mol. Spec.*, 356, 39-45, <https://doi.org/10.1016/j.jms.2019.01.001>.

Intercomparison of open-path trace gas measurements with two dual-frequency-comb spectrometers. E.M. Waxman, K.C. Cossel, G.-W. Truong, F.R. Giorgetta, W.C. Swann, S. Coburn, R.J. Wright, G.B. Rieker, I. Coddington, N.R. Newbury (2017), *Atmos. Meas. Tech.*, 10, 3295-3311, <https://doi.org/10.5194/amt-10-3295-2017>.

Open-path dual-comb spectroscopy to an airborne retroreflector. K.C. Cossel, E.M. Waxman, F.R. Giorgetta, M. Cermak, I.R. Coddington, D. Hesselius, S. Ruben, W.C. Swann, G.-W. Truong, G.B. Rieker, N.R. Newbury (2017), *Optica*, 4, 724-728, <https://doi.org/10.1364/OPTICA.4.000724>.

Can COSMOthermX Predict a Salting in Effect? M. Toivola, N. Prisle, J. Elm, E. Waxman, R. Volkamer, T. Kurtén. (2017), *J. Phys. Chem. A*, 121 (33) 6288-6295, doi:10.1021/acs.jpca.7b04847.

Potential of aerosol liquid water to facilitate organic aerosol formation: assessing knowledge gas about precursors and partitioning. N. Sareen, E.M. Waxman, B.J. Turpin, R. Volkamer, A.G. Carlton (2017), *Environ. Sci. Technol.*, 51 (6), 3327-3335, 2017. doi: 10.1021/acs.est.6b04540.

Gas-phase broadband spectroscopy using active sources: Progress, status, and applications. K.C. Cossel, E.M. Waxman, G.A. Blake, I.A. Finneran, J. Ye, N.R. Newbury (2017), *J. Opt. Soc. Am. B*, 34, 104-129, <https://doi.org/10.1364/JOSAB.34.000104>.

Fieldable dual-comb spectrometer for high-precision near-infrared spectroscopy spanning 44 THz. G.W. Truong, E.M. Waxman, K.C. Cossel, E. Baumann, A.M. Klose, F.R. Giorgetta, W.C. Swann, N.R. Newbury, I.R. Coddington (2016), *Optics Express*, 24, 30495-30504, <http://dx.doi.org/10.1364/OE.24.030495>.

Measurements of Hydroxyl and Hydroperoxy Radicals during CalNex-LA: Model Comparisons and Radical Budgets. S. Griffith, R. Hansen, S. Dusanter, V. Michoud, J. Gilman, W. Kuster, P. Veres, M. Graus, J. de Gouw, J. Roberts, C. Young, R. Washenfelder, S.S. Brown, R. Thalman, E. Waxman, R. Volkamer, C. Tsai, J. Stutz, J. Flynn, N. Grossberg, B. Lefer, S. Alvarez, B. Rappenglueck, L. Mielke, H. Osthoff, and P.S. Stevens (2016), *J. Geophys. Res. – Atmos.*, 121, 4211-4232, doi: 10.1002/2015JD024358.

Modeling the weekly cycle of NO<sub>x</sub> and CO emissions and their impacts on O<sub>3</sub> in the Los Angeles-South Coast Air Basin during the CalNex 2010 field campaign. S.W. Kim, B. McDonald, S. Baidar, S. S. Brown, W.P. Dube, R. Ferrare, G. Frost, R. Harley, J.S. Holloway, H.J. Lee, S. McKeen, J. Neuman, J. Nowak, H. Oetjen, I. Ortega, I. Pollack, J. Robert, T. Ryerson, A. Scarino, C. Senff, R. Thalman, M. Trainer, R. Volkamer, N. Wagner, R. Washenfelder, E. Waxman, C. Young (2016), *J. Geophys. Res. Atmos.*, 121, 1340-1360, doi: 10.1002/2015JD024292

Glyoxal and Methyl Glyoxal Setschenow Salting Constants in Sulfate, Nitrate, and Chloride Solutions: Measurements and Gibbs Energies. E.M. Waxman, J. Elm, T. Kurten, K. Mikklesen, P. Ziemann, R. Volkamer, (2015), *Environ. Sci. Technol.*, 49, 11500-11508. doi: 10.1021/acs.est.5b02782

Measurements of the absorption cross section of <sup>13</sup>CHO<sup>13</sup>CHO at visible wavelengths and application to DOAS retrievals. N.R. Goss, E.M. Waxman, S.C. Coburn, T.K. Koenig, R. Thalman, J. Dommen, J.W. Hannigan, G.S. Tyndall, and R. Volkamer (2015), *J. Phys. Chem. A Mario Molina Festschrift.*, 19, 4651-4657. doi: 10.1021/jp511357s.

A Computational Study of the Effect of Glyoxal-Sulfate Clustering on the Henry's Law Coefficient of Glyoxal. T. Kurten, J. Elm, N.L. Prisle, K.V. Mikkelsen, C.J. Kamp, E.M. Waxman, R. Volkamer (2015), *J. Phys. Chem. A*, 19, 4509-4514. doi: 10.1021/jp510304c.

Instrument inter-comparison of glyoxal, methyl glyoxal, and NO<sub>2</sub> under simulated atmospheric conditions. R. Thalman, M. T. Baeza-Romero, S.M. Ball, E. Borrás, M.J.S. Daniels, I.C.A. Goodall, S.B. Henry, T. Karl, F.N. Keutsch, S. Kim, J. Mak, P.S. Monks, A. Muñoz, J. Orlando, S. Peppe, A.R. Rickard, M. Rodenas, P. Sanchez, R. Seco, L. Su, G. Tyndall, M. Vazquez, T. Vera, E. Waxman, and R. Volkamer (2014), *Atmos. Meas. Tech.*, 8, 1835-1862. doi: 10.5194/amt-8-1835-2015.

Simulation of semi-explicit mechanisms of SOA formation from glyoxal in a 3D model. C. Knote, A. Hodzic, J.L. Jimenez, R. Volkamer, J.J. Orlando, S. Baidar, J. Brioude, J. Fast, D.R. Gentner, A.H. Goldstein, P.L. Hayes, W.B. Knighton, H. Oetjen, A. Setyan, H. Stark, R. Thalman, G. Tyndall, R. Washenfelder, E. Waxman, and Q. Zhang (2014), *Atmos. Chem. Phys.*, 14, 6213-6239. doi:10.5194/acp-14-6213-2014

Aerosol Composition and Sources in Los Angeles During the 2010 CalNex Campaign. P.L. Hayes, A.M. Ortega, M.J. Cubison, K.D. Froyd, Y. Zhao, S.S. Cliff, W.W. Hu, D.W. Toohey, J.H. Flynn, B.L. Lefer, N. Grossberg, S. Alvarez, B. Rappengluck, J.W. Taylor, J.D. Allan, J.S. Holloway, J.B. Gilman, W.C. Custer, J.A. de Gouw, P. Massoli, X. Zhang, J. Liu, R.J. Weber, A.L. Corrigan, L.M. Russell, G. Isaacman, D.R. Worton, N.M. Kreisberg, A.H. Goldstein, R. Thalman, E.M. Waxman, R. Volkamer, Y.H. Lin, J.D. Surratt, T.E. Kleindienst, J.H. Offenberg, S. Dusanter, S. Griffith, P.S. Stevens, J. Brioude, W.M. Angevine, J.L. Jimenez (2013), *J. Geophys. Res.-Atmos.*, 118(16), 9233-9257. doi: 10.1002/jgrd.50530.

Henry's Law constants of glyoxal in model aerosols containing sulfate. C.J. Kampf, E.M. Waxman, J.G. Slowik, J. Dommen, L. Pfaffenberger, A.P. Praplan, A.S.H. Prevot, U. Baltensperger, T. Hoffmann, and R. Volkamer (2013), *Environ. Sci. Technol.*, 47(9), 4236-4244. doi: 10.1021/es400083d

Secondary Organic Aerosol Formation from S/IVOC and glyoxal: Relevance of O/C as a tracer for aqueous multiphase chemistry. E.M. Waxman, K. Dzepina, B. Ervens, J. Lee-Taylor, B. Aumont, J.L. Jimenez, S. Madronich, R. Volkamer (2013), *Geophys. Res. Lett.*, 40(5), 978-982 doi: 10.1002/GRL.50203.

Imaging and Thermal Studies of Wheat Gluten/Poly(vinyl alcohol) and Wheat Gluten/Thiolated Poly(vinyl alcohol) Blends. J. Dong, R. Dicharry, E. Waxman, R.S. Parnas, A.D. Asandei (2008) *Biomacromolecules*, 9(2), 568-573.

Wheat Gluten-Thiolated Poly(vinyl alcohol) Blends with Improved Mechanical Properties. R.M. Dicharry, P. Ye, G. Saha, E. Waxman, A.D. Asandei, R.S. Parnas (2006), *Biomacromolecules*, 7(10), 2837-2844.

## **PRESENTATIONS (invited talks in bold)**

Measurement of Trace Gases from an Unconventional Oil and Gas Development Site Using Mid-Infrared Dual Comb Spectroscopy, E. Waxman, K. Cossel, F. Giorgetta, E. Baumann, G. Ycas, D. Herman, J. Friedlein, D. Bon, I. Coddington, and N. Newbury, AGU Fall Meeting, Virtual, December 2020

Measurement of Trace Gases from an Unconventional Oil and Gas Development Site Using Mid-Infrared Dual Comb Spectroscopy, E. Waxman, K. Cossel, F. Giorgetta, E. Baumann, G. Ycas, D. Herman, J. Friedlein, D. Bon, I. Coddington, and N. Newbury, OSA Optical Sensors and Sensing Congress, Virtual, June 2020

**Dual Comb Spectroscopy for Emissions Measurements, E. Waxman, K. Cossel, GF. Giorgetta, W. Swann, G.-W. Truong, M. Cermack, D. Hesselius, I. Coddington, N. Newbury, Physics Department, University of Vienna, Vienna, Austria, March 2020**

**Trace gas sensing in the near and mid-infrared using dual comb spectroscopy, E. Waxman, K. Cossel, M. Cermack, I. Coddington, J. Friedlein, D. Herman, W. Swann, G.-W. Truong, G. Ycas, N. Newbury, Precision and Quantum Sensing Workshop, Adelaide, Australia, Nov. 2019**

**Dual Comb Spectroscopy for Emissions Measurements, E. Waxman, K. Cossel, GF. Giorgetta, W. Swann, G.-W. Truong, M. Cermack, D. Hesselius, I. Coddington, N. Newbury, American Physical Society March Meeting, Boston, MA, Mar. 2019**

Emissions Quantification Using Dual Frequency Comb Spectroscopy, E. Waxman, K. Cossel, G.W. Truong, F. Giorgetta, W. Swann, D. Hesselius, M. Cermack, I. Coddington, N. Newbury, American Geophysical Union Fall Meeting, Washington, D.C., December 2018 (Poster)

**Estimating CO<sub>2</sub> emissions from Boulder using horizontal path-integrated dual frequency comb spectroscopy, E. Waxman, Applied Physics Division Seminar, NIST, Boulder, CO, May 2018**

City-Scale Traffic Emissions from Long-Path Measurements, E. Waxman, K. Cossel, G.W. Truong, F. Giorgetta, W. Swann, I. Coddington, N. Newbury, American Meteorological Society Annual Meeting, Austin, TX, Jan. 2018 (Talk)

Open Path Greenhouse Gas Measurements Over a Medium-Sized City, E. Waxman, K. Cossel, G.-W. Truong, F. Giorgetta, W. Swann, I. Coddington, N. Newbury, American Geophysical Union Fall Meeting, New Orleans, LA, Dec. 2017 (poster)

Dual Frequency Comb Spectroscopy for Trace Gas Monitoring Over Open-Air Paths, E. Waxman, K. Cossel, G.-W. Truong, F. Giorgetta, B. Swann, I. Coddington, N. Newbury, Congress on Energy and the Environment, Boulder, CO, Nov. 2017 (Talk)

**Open-Path Dual Comb Spectroscopy for Atmospheric Measurements, N. Newbury, K. Cossel, E. Waxman, G. Ycas, F. Giorgetta, S. Coburn, I. Coddington, D. Herman, G. Rieker, R. Wright, SCIX Conference, Reno, NV, Oct. 2017**

Dual Frequency Comb Measurements of Greenhouse Gases Over Boulder, E. Waxman, K. Cossel, G.-W. Truong, F. Giorgetta, W. Swann, S. Coburn, R. Wright, G. Rieker, I. Coddington, N. Newbury, Global Monitoring Annual Conference, Boulder, CO, May 2017 (Talk)

Open Path Greenhouse Gas Measurements over a Medium-Sized City, E. Waxman, K. Cossel, C. Alden, G.W. Truong, F. Giorgetta, W. Swann, I. Coddington, N. Newbury, American Geophysical Union Fall Meeting, San Francisco, CA, Dec. 2016. (Poster)

Long-path atmospheric measurements using dual frequency comb measurements, E. Waxman, K. Cossel, G.W. Truong, F. Giorgetta, W. Swann, I. Coddington, N. Newbury, European Geosciences Union General Assembly 2016, Vienna, Austria, April 2016. (Poster)

Laboratory-based Dual Frequency Comb Spectrometer for Atmospheric Chemistry Measurements, E. Waxman, G.W. Truong, K. Cossel, I. Coddington, N. Newbury, American Geophysical Union Fall Meeting, San Francisco, CA, Dec. 2015. (Poster)

Effect of Ammonia on Glyoxal SOA in Inorganic Aqueous Seed Particles, E. Waxman, A. Laskin, J. Slowik, A. Maxut, S. Wang, J. Zhen Yu, T. Koenig, J. Laskin, A. Prevot, U. Baltensperger, B. Noziere, J. Dommen, R. Volkamer, American Geophysical Union Fall Meeting, San Francisco, California, Dec. 2014. (Talk)

Salting Constants of Small Organic Molecules in Aerosol-Relevant Salts and Application to Aerosol Formation in the Southeastern United States, E. Waxman, T. Kurtén, J. Elm, N. Prisle, K. Mikkelsen, N. Sareen, P. Ziemann, A. Carlton, R. Volkamer, American Geophysical Union Fall Meeting, San Francisco, CA, Dec. 2014. (Poster)

Effect of Ammonia on Glyoxal SOA in Inorganic Aqueous Seed Particles, E. Waxman, A. Laskin, J. Slowik, A. Maxut, S. Wang, J. Zhen Yu, T. Koenig, J. Laskin, A. Prevot, U. Baltensperger, B. Noziere, J. Dommen, R. Volkamer, American Association for Aerosol Research, Orlando, FL, Oct. 2014. (Talk)

Secondary Organic Aerosol Formation from Glyoxal: Salting Behavior and Kinetics of SOA Formation and its Dependence on Aerosol Seed Composition, E. Waxman, J. Slowik, C. Kampf, S. Wang, J. Timkovsky, T. Koenig, T. Hoffmann, B. Noziere, R. Holzinger, A. Prevot, J. Dommen, J. Yu, R. Volkamer, American Association for Aerosol Research, Portland, OR, Oct. 2013. (Poster)

Application of <sup>12</sup>C and <sup>13</sup>C glyoxal to laboratory experiments, E. Waxman, N. Goss, T. Koenig, R. Thalman, R. Volkamer, 6<sup>th</sup> International DOAS Workshop, Boulder, CO, Aug. 2014. (Talk)

Aqueous aerosol-phase chemistry resulting in the formation of secondary organic aerosol: Testing laboratory evidence with field data, E. Waxman, K. Dzepina, B. Ervens, J. Lee-Taylor, B. Aumont, J.-L. Jimenez, S. Madronich, R. Volkamer, American Association for Aerosol Research, Minneapolis, MN, Oct. 2012. (Talk)

Secondary Organic Aerosol Formation from Glyoxal: reversible versus irreversible SOA formation, E. M. Waxman, J. Slowik, C. Kampf, J. Timkovsky, B. Nozière, A. P. Praplan, L. Pfaffenberger, R. Holzinger, T. Hoffmann, J. Dommen, A. Prévôt, U. Baltensperger, R. Volkamer, American Geophysical Union Fall Meeting, San Francisco, CA, Dec. 2011. (Talk)

Aqueous aerosol-phase chemistry resulting in the formation of secondary organic aerosol: Testing laboratory evidence with field data, E. Waxman, B. Ervens, K. Dzepina, R. Volkamer, American Chemical Society Fall 2011 National Meeting, Denver, CO Aug. 2011. (Talk)

DOAS measurement applications to modeling: A case study of SOA formation in Mexico City, E. Waxman, B. Ervens, R. Volkamer, Fifth International DOAS Workshop, Mainz, July 2011. (Poster)

Secondary Organic Aerosol Formation from Glyoxal: Linking laboratory, field and model studies, E. Waxman, B. Ervens, R. Volkamer, American Geophysical Union Fall Meeting, San Francisco, CA Dec. 2010. (Poster)

Secondary Organic Aerosol Formation from Glyoxal: Linking laboratory, field and model studies, E. Waxman, B. Ervens, R. Volkamer, Atmospheric Chemical Mechanisms, Davis, CA Dec. 2010. (Poster)

## **TEACHING EXPERIENCE**

**CHEM 4181, Instrumental Analysis Laboratory with Environmental Emphasis**, University of Colorado Boulder, Spring 2014, Instructor of Record, 21 students in class

- Developed entirely new lecture material for data analysis and scientific writing with a focus on active learning, small group work, and critical thinking.
- Assisted in the development of a new experiment using ATR-FTIR.

**CHEM 1211/ CHEM 1221, General Chemistry for Engineers and Engineering General Chemistry Lab**, University of Colorado at Boulder, Fall 2013, Lead TA

- Developed recitation material including weekly examples of how chemistry topics are used in the real world in a variety of applications including environmental, biological and medical, and transportation examples.
- Developed non-traditional interactive recitation materials including science bingo and exam review jeopardy.

- Taught guest lecture on acid base chemistry to a lecture of 320 students.
- Assisted with course management including proofing exams, running exams when the professor was out of town, and semi-quantitative statistical analysis of course grades.
- Taught one recitation section and lab in the course and graded homework and lab reports for this section.

**CHEM 4181, Instrumental Analysis Laboratory**, University of Colorado Boulder, Spring 2013, Lead TA

- Tested and assisted with the development of new labs including atomic absorption and HITRAN modeling component for FTIR.
- Developed course material for scientific writing.
- Ran one laboratory section and graded homework and lab reports.

**CHEM 1113, General Chemistry**, University of Colorado Boulder, Fall 2012, TA

- Sole TA for a special Health Providers Residential Academic Program section of General Chemistry.
- Created short recitation lectures (~10-15 minutes) on how chemistry is important for medicine using topics covered in class, e.g. radionuclides in diagnostic tests, and the importance of molecular shapes in developing drugs.
- Created and presented an exam review on the laboratory material.
- Taught one guest lecture on the ideal gas law and modifications for real gases, including developing clicker questions.
- Taught two recitations and laboratory sections and graded lab reports for these sections.

**CHEM 4171, Instrumental Analysis**, University of Colorado at Boulder, September 2011, September 2012, and September 2013, Substitute Instructor.

- Developed and presented two lectures on calibration curves, one on HPLC, two on FTIR, and an Excel data analysis and graphing tutorial.

**CHEM 4181, Instrumental Analysis Laboratory with Environmental Emphasis**, University of Colorado at Boulder, Spring and Summer 2009, TA

- Helped students develop capstone independent projects using one or more techniques listed above.
- Developed curriculum to align laboratory experiments with available equipment, change course emphasis to instrumentation, and move to more sustainable experiments.
- Developed a fluorescence lab investigating quinine in tonic water, rewrote lab manual, and developed homework assignments.

**CHEN 1211/CHEM 1221, General Chemistry for Engineers and Engineering General Chemistry Lab**, University of Colorado at Boulder, Fall 2008, Teaching Assistant

- Developed and presented recitation material based on weekly lectures, wrote and graded weekly quizzes **Chem 1a/b, General Chemistry**, Caltech, Fall 2007-Winter 2008, Undergraduate Teaching Assistant

- Developed and presented recitation material based on weekly lecture material, wrote quiz and exam questions

**Chem 4b & Chem 3b, Synthesis and Analysis of Organic and Inorganic Compounds & Experimental Procedures of Synthetic Chemistry**, Caltech, Winter 2007 & Spring 2007, Undergraduate Teaching Assistant

- Supervised chemical engineering student experiments twice weekly in the lab. Included office hours, grading lab reports, and NMR maintenance.

**SERVICE**

- Reviewer for: Atmospheric Measurement Techniques, Atmospheric Chemistry and Physics, Environmental Science and Technology, JGR-Atmospheres, Atmosphere, Journal of Oceanic and Atmospheric Technology (?)
- Editor for Atmosphere since Nov. 2019
- Reviewer for: DoE SBIR proposals

**OUTREACH & COMMUNITY SERVICE**

Mentor, Summer High school Internship Program, NIST-Boulder, Summer 2016

Reviewer for Environmental Science and Technology, Atmospheric Chemistry and Physics, Atmospheric Measurement Techniques

Outstanding Student Poster Award judge, AGU Fall Meeting, 2016

High school student research mentor, February – August 2016

CU Wizards assistant, November 2014, Speed

Boulder Valley Science Fair Judge, February 2012, Middle school judge